AEROFLEX

Aerodynamic and Flexible Trucks for Next Generation of Long Distance Road Transport

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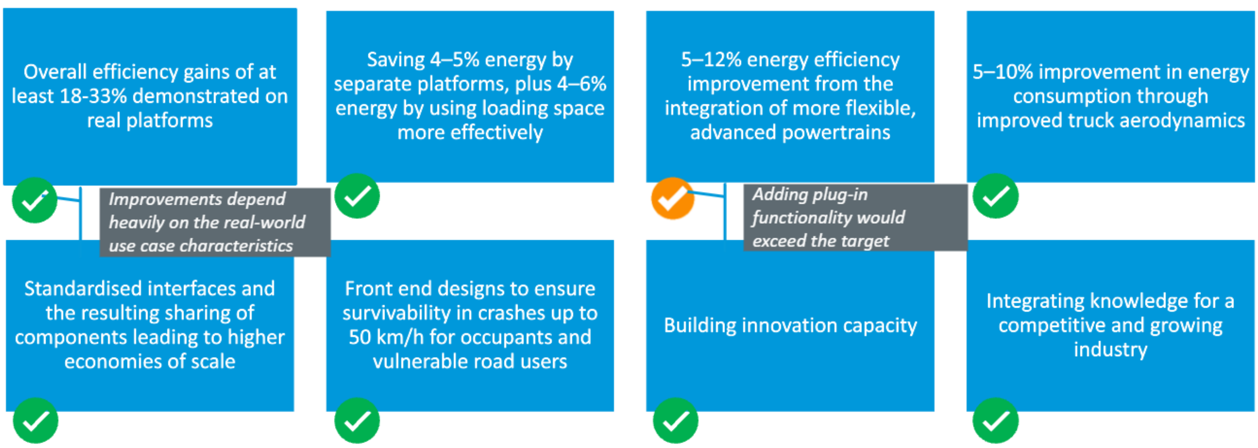
Publishable Executive Summary

The vision of the AEROFLEX project is to support vehicle manufacturers and the logistics industry to meet the future challenges for road transport. The goal of the AEROFLEX project is to develop and demonstrate new technologies, new concepts, and new architectures for complete vehicles with optimised aerodynamics, powertrains, and safety systems as well as flexible and adaptable loading units with advanced interconnectedness contributing to the vision of a "Physical Internet". These new vehicle concepts and innovations need to be assessed in terms of their impact on transport efficiency and CO_2 emissions for which in the AEROFLEX project an assessment framework has been developed. It is used to calculate the impact of the demonstrator vehicles and a variety of other combinations of vehicle configurations and innovations.

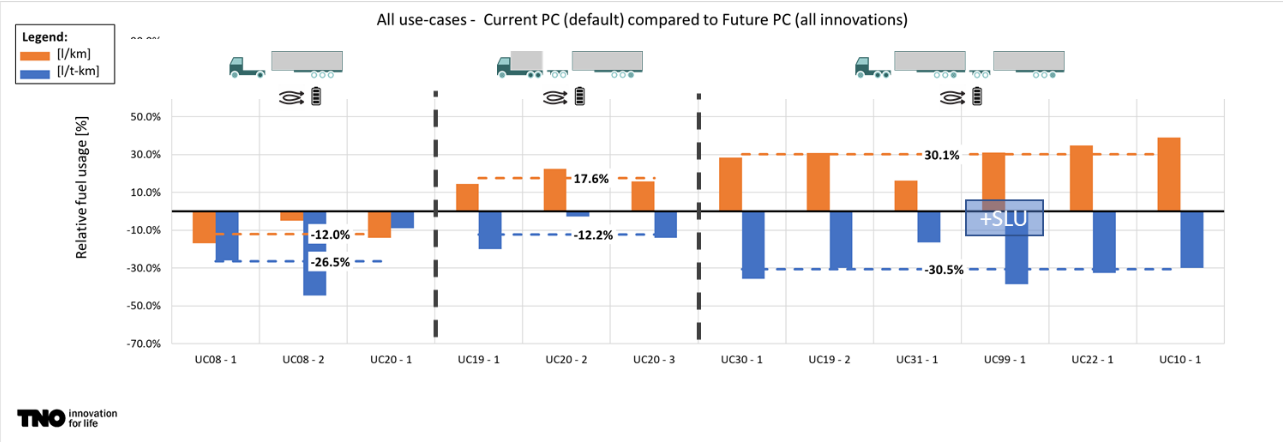
EMS (European Modular Systems) or HCV (High-Capacity Vehicles) play an important role achieving the goals of the AEROFLEX project. The philosophy of the AEROFLEX project is that optimised aerodynamics, distributed powertrains, and adaptable loading units enable the EMS pulling units to be relatively simple, cheap and fuel efficient. In this way, transport efficiency could benefit most and the best cost-benefit ratio could be reached. In the project both EMS1 (25.25 m) and EMS2 (32 m) vehicle configurations are tested and evaluated. Reference vehicles are tested and evaluated and the AEROFLEX EMS1 and EMS2 demonstrator vehicles incorporating the AEROFLEX innovations have been subjected to various on-road tests.

A unique factor in this project is the use of so-called "customer use-cases". In the project, more than 50 companies in the logistics sector are interviewed and a selection of these companies are used to describe actual use-cases [1]. This selection is used in the evaluation phase of the AEROFLEX project, to make sure that the potential of the vehicle configurations and innovations are based on realistic and actual situations in logistics. For this evaluation phase, an assessment framework is developed to accommodate customer use-cases, TEN-T routes (Trans-European Transport Network) and the AEROFLEX vehicle configurations and innovations. Using this framework, the impact on transport efficiency, CO_2 emissions and cost-benefit can be calculated, using the same routes the operators of the customer use-cases perform, including elevation profiles and traffic conditions. Also, the assessment framework allows for the finetuning of the vehicle configurations and specifications, as well as the combination and specifications of the AEROFLEX innovations, according to the specific needs of each customer use-case. The assessment framework described D6.2 focusses on transport efficiency and cost-benefit of vehicle concepts in logistic use-cases. Other impacts of high-capacity vehicles, such as infrastructure wear, bridge capacity and safety performance are not part of the assessment framework and this report. The vehicle dynamic behaviour (e.g. gradeability, startability, acceleration capability, tail swing, high speed transient off-tracking and swept path) is described in AEROFLEX Deliverable D6.5 [2].



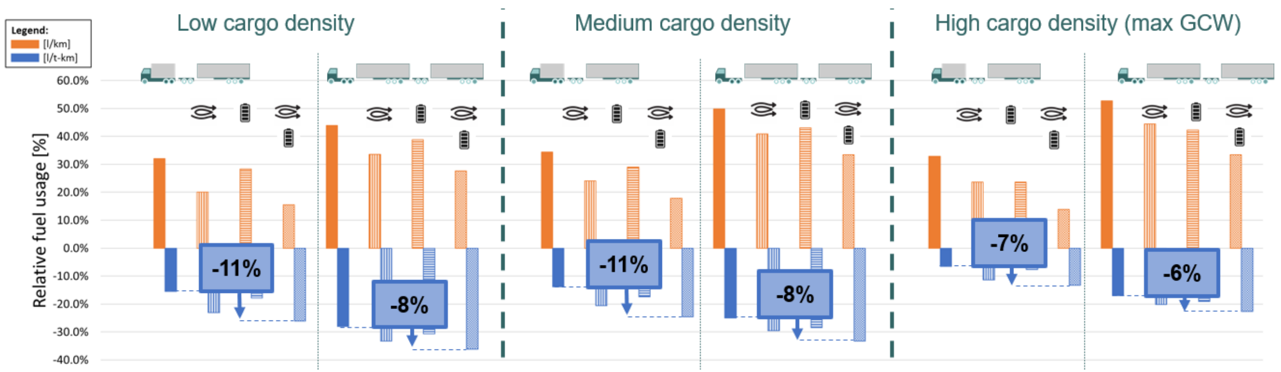
The goals as defined for the AEROFLEX project are shown in the figure above. In short: the project achieved the goals. Two important side notes have to be made: first, the overall efficiency gains depend heavily on the real-world use case characteristics. For this reason, the impact assessment is conducted using eight very different use-cases from logistic partners. One of the conclusions of this project is that mimicking the real-world operation is essential to bridge to the world of the end-users. Second, in order to achieve the goals set for flexible, advanced powertrain, the project learned that plug-in functionality of the e-dolly and/or e-trailer is needed to meet and exceed the goal.

The overall impact of new vehicle concepts incorporating the AEROFLEX innovations on transport efficiency and CO_2 emission can exceed a 50% reduction on a t-km (tonne-kilometre) basis. This is in comparison to the current operation (tractor-semitrailer in most cases), the reduction is valid for a specific customer use-case and this reduction potential is on the high end of the spectrum. The figure below shows an overview of the impact of the new vehicle concepts including the AEROFLEX innovations for different use-cases, all referenced to a baseline of tractor-semitrailer operations. In these results, one must distinguish between the impact on the fuel consumption in l/km (litre per kilometre, the orange bars) and the impact on transport efficiency in l/t-km (litre per tonne-kilometre, the blue bars).



Fuel consumption increases when using longer (EMS1 and EMS2) vehicles (orange bars), but the AEROFLEX innovations mitigate some of those increases and effectively reduce the fuel consumption by 10-15%. Looking at all use-cases assessed, the transport efficiency gains vary between 20 and 40%, obviously dictated by the cargo transported, the vehicles used and routes driven. As said, in extreme cases the gain can exceed 50%.

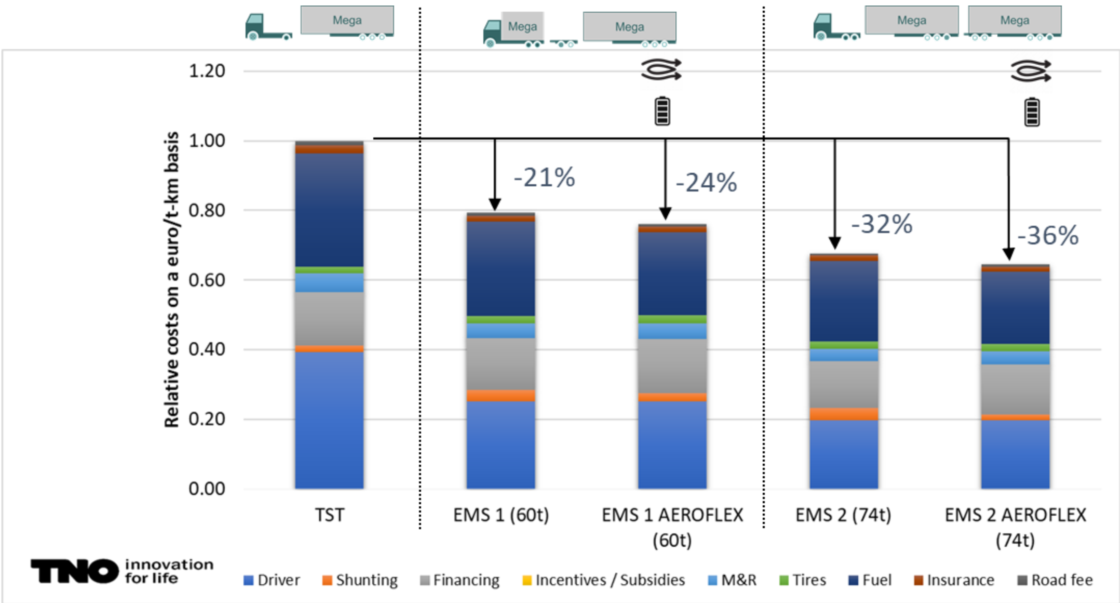
The impact of new vehicle configurations (versus tractor-semitrailer) including AEROFLEX innovations was calculated for TEN-T routes as well. In the figure below the results are shown for one of the two calculated corridors (TEN-T Corridor Rhine-Alpine). Calculating these routes allows for varying the cargo transported in terms of the payload. Smart loading units (SLU) in the form of the double load floor are not included in these results.



From this graph, it becomes apparent that low cargo density (thus low payload) shows the highest impact, well exceeding 35% (light blue bars) for the combined effect of new vehicle configurations and AEROFLEX innovations. The high payloads up to max allowed gross combination weight (GCW) show an impact exceeding 20%. The reason for this lower impact can partly be found in limiting the cargo due to the weight of the innovations. In other words: the impact could be increased if the max GCW would be compensated for the weight of the innovations. The impact of the innovations excluding SLU (as shown in the blue boxes) within a certain vehicle category are 6 – 11% on a l/t-km basis.

When combining the assessment results of the customer use-cases and TEN-T corridors, it can be concluded that The impact on fuel efficiency of the AEROFLEX innovations within a certain vehicle configuration varies between 10 and 14% on a l/km basis due the aerodynamic devices and the advanced distributed powertrain. Compensating for the higher weight of these innovations, the transport efficiency improves by 7-10% on a l/t-km basis. When adding smart loading units (i.e. double load floor) the transport efficiency gains on a l/t-km basis may well exceed 17% in specific cases. The combined impact of the aerodynamic innovations and the advanced distributed powertrain is in some cases higher than the sum of the impact of the separate innovations. In other words: the innovations support each other.

For two customer use-cases a cost-benefit analysis is conducted: a mass limited and a volume limited case. The results for the volume limited case are shown below, for EMS1 and EMS2 vehicle configurations (both with and without AEROFLEX innovations) compared to a baseline tractor-semitrailer (TST). The key parameters/factors that define the cost structure are fuel, equipment (financing) and driver. The results are on a euro/t-km basis.



The volume limited case shows cost reductions up to 24% for EMS1 and 36% for EMS2. Also, the impact of the AEROFLEX innovations (excl. SLU or double load floor) on costs is positive. These results are slightly lower for the mass limited case. It should be noted that not all societal benefits are monetised here such as the contribution to lower (pollutant) emissions and to reducing the truck driver shortage. These results are valid for only one customer use-case, broken down in a volume limited and mass limited part. Since this is a use-case with rather limited fuel consumption impact, it is expected that the impact on costs using this use-case is rather conservative as well.

Outside the scope of the project, but important to highlight, is the impact of the AEROFLEX innovations on zero-emission (ZE) logistics. The qualitative impact is two-fold: first, the AEROFLEX projects has resulted in the distributed powertrain concept with an e-dolly and/or e-trailer, which can support a ZE pulling unit and therefore making the challenge of long-distance ZE freight transport better achievable. Second, the AEROFLEX innovations reduce the energy need for the complete vehicle combination: less energy need means more range with the same battery capacity and/or fuel cell in the pulling unit or the same range with a smaller battery and/or fuel cell.

It is recommended to use the assessment framework as developed in the AEROFLEX project for the transition towards ZE logistics. Again, using real-world logistic use-cases and preferably together with the end customers. The AEROFLEX project is rather unique using so many customer use-cases from logistic partners close to the project. It is highly recommended to extend this way of working. Using a wide variety of customer use-cases shows the spread in results and helps understanding the specific added value of new vehicle configurations and innovations in various situations. Obviously some innovations have added value in some use-cases and in others only limited or none at all. Another benefit of using real-world use-cases is the direct contact with the end customers. These customers not only bring sense in choosing parameter settings in the impact assessment, but also are a sounding board for the results obtained and the future potential to really implement the innovations.

The assessment framework developed in the AEROFLEX project can be rather easily adapted to calculate the impact of zero-emission vehicles including all sorts of innovations. Perhaps even more important: the framework can be adapted for use in the complex decision-making process logistic operators have to face: what zero-emission vehicle to use on what route, where to charge/refuel, how to scale up zero-emission operations etc.